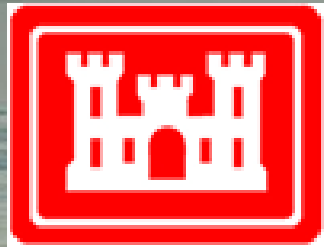# LTMS Juvenile Salmonid Outmigration and Distribution in the San Francisco Estuary 2009-10

LONG TERM MANAGEMENT STRATEGY (LTMS)

US Army Corps of Engineers

Biotelemetry Lab, UC Davis

Eric Chapman, Alex Hearn, Mike Thomas,

Pete Klimley (PI)

Outline

- **Study question and objectives**
- **Study site**
- **Field methods**
- **Results to date and expected results**
- **2010 time frame**
- **Future steps and synergy**

Study Objective

To determine potential exposure of migrating salmonids to adverse affects of dredging activity.

Study Questions

1. What are the general migratory patterns of salmonid smolts through SF Bay in relation to dredge and dredge placement sites?

2. What is the residence time of these fish
    A) in particular reaches of the estuary (transit time) and
    B) at sites of interest (exposure time)?

3. What are the spatial and temporal distribution patterns of green sturgeon in the estuary?

Study Species

Late-fall Chinook Salmon

Steelhead

Year	Fish tagged
2006/7	49
2007/8	50
2008/9	500
2010	500

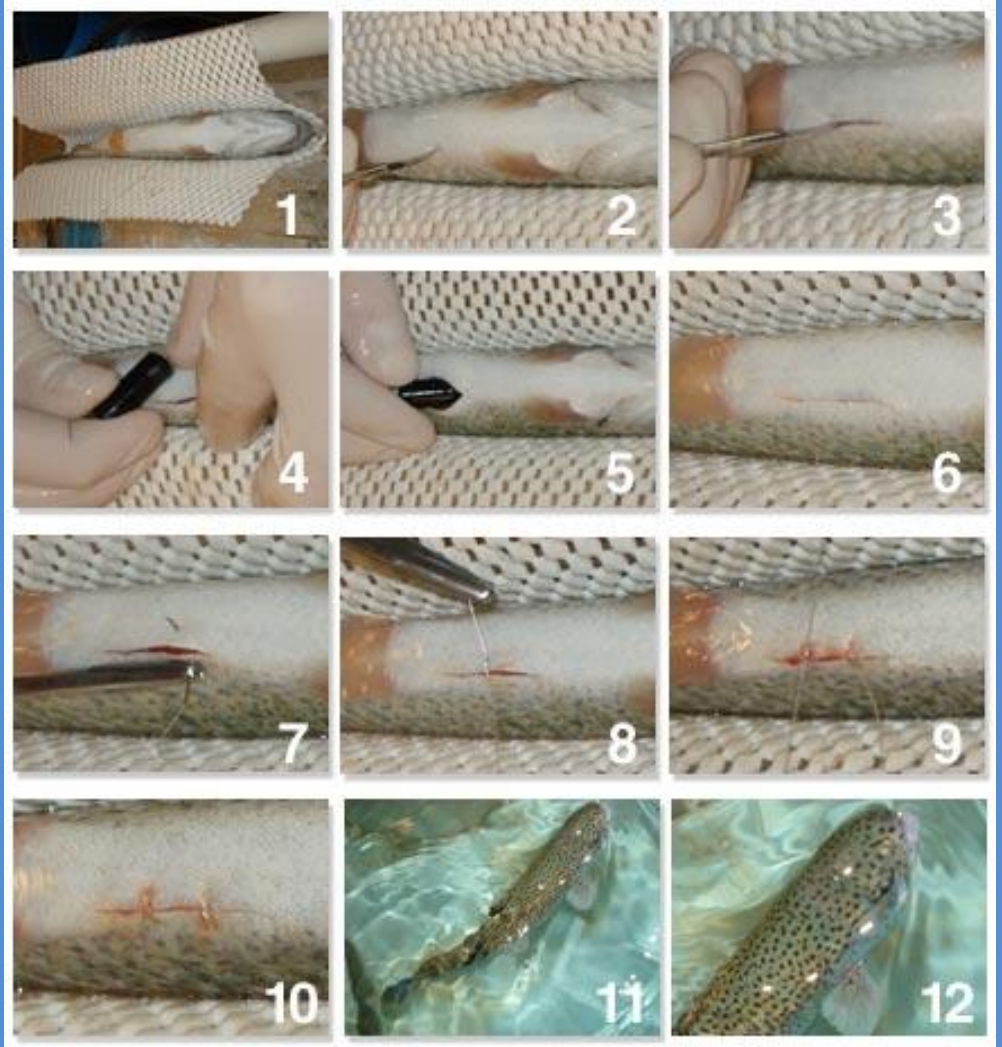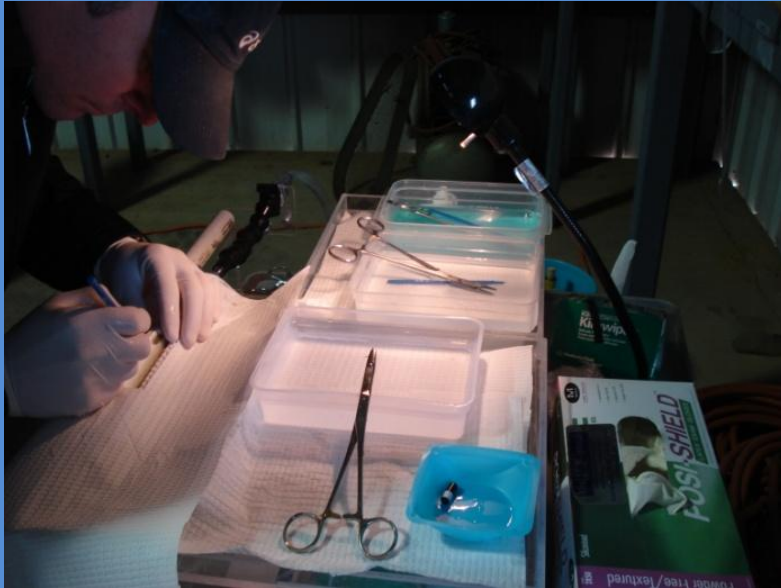| Year	Fish tagged
2006/7	49
2007/8	50
2008/9	500
2010	500

New Species: Green Sturgeon

Over **300** green sturgeon tagged in the last 5 years, 80 more per year over the next 3 years

Several projects look at effects of Red Bluff Dam, migration upriver, juvenile habitat use etc.

Current perception that adult green sturgeon are in the estuary all year round and over the entire area. **Is this really the case?**
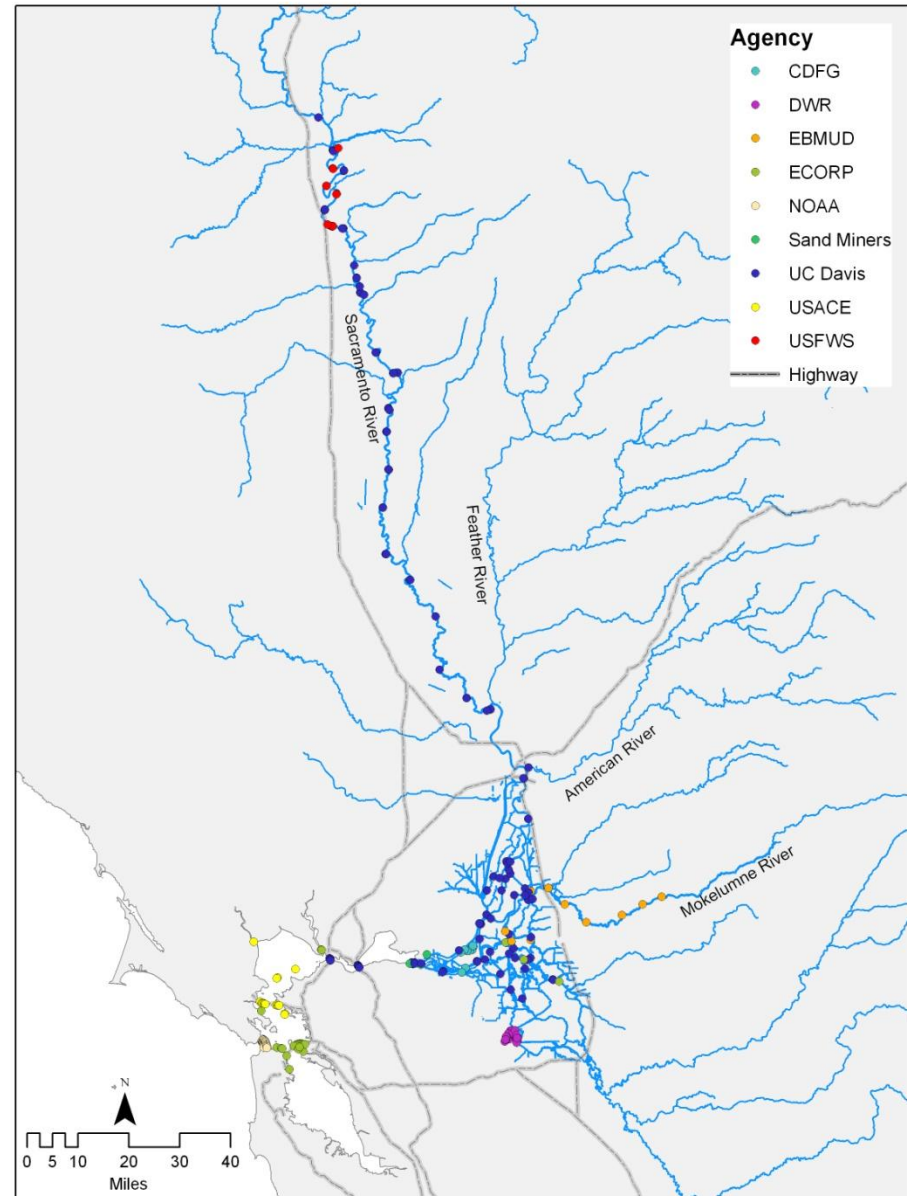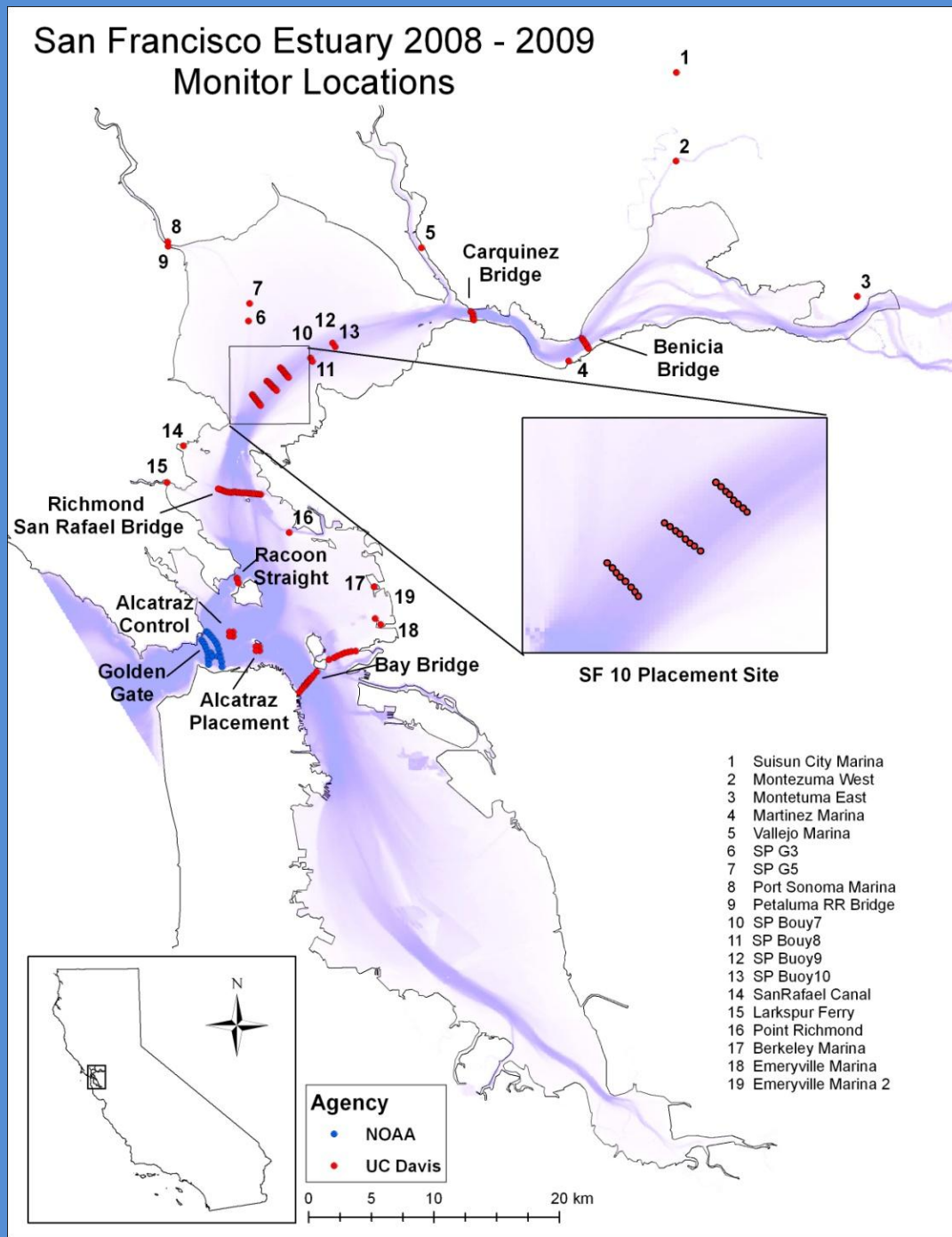
Fish Tagging

Monitor Array

**>200 deployed
by CFTC members,
most are maintained by
Biotelemetry Lab.**

Agency
- CDFG
- DWR
- EBMUD
- ECORP
- NOAA
- Sand Miners
- UC Davis
- USACE
- USFWS
- Highway

Sacramento River

Feather River

American River

Mokelumne River

N

0 5 10   20   30   40
Miles

Study Array

San Francisco Estuary 2008 - 2009
Monitor Locations

Carquinez Bridge

Benicia Bridge

SF 10 Placement Site

Richmond San Rafael Bridge

Racoon Straight

Alcatraz Control

Golden Gate

Alcatraz Placement

Bay Bridge

1 Suisun City Marina
2 Montezuma West
3 Montetuma East
4 Martinez Marina
5 Vallejo Marina
6 SP G3
7 SP G5
8 Port Sonoma Marina
9 Petaluma RR Bridge
10 SP Bouy7
11 SP Bouy8
12 SP Buoy9
13 SP Buoy10
14 SanRafael Canal
15 Larkspur Ferry
16 Point Richmond
17 Berkeley Marina
18 Emeryville Marina
19 Emeryville Marina 2

N

Agency
● NOAA
● UC Davis

0   5   10   20 km
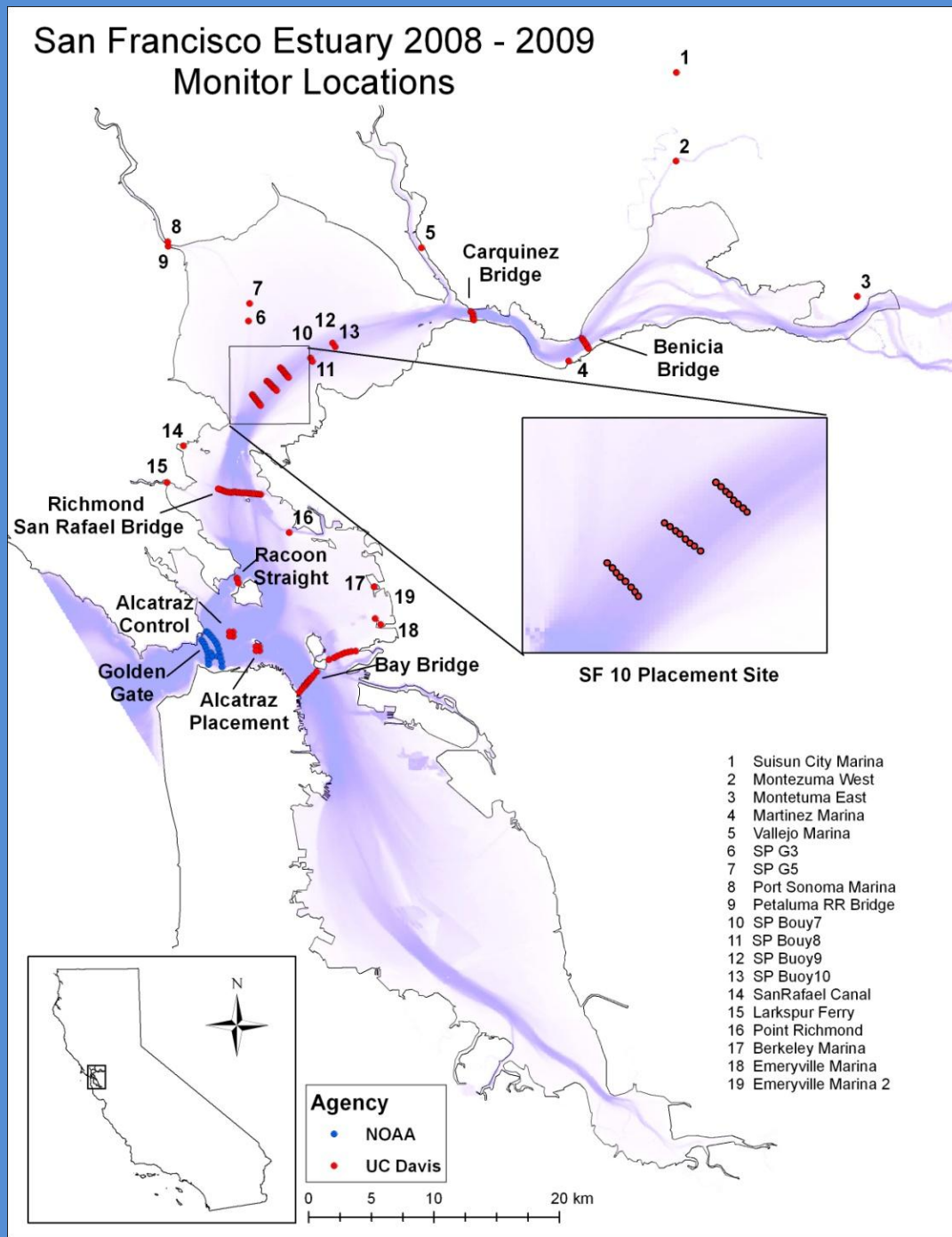
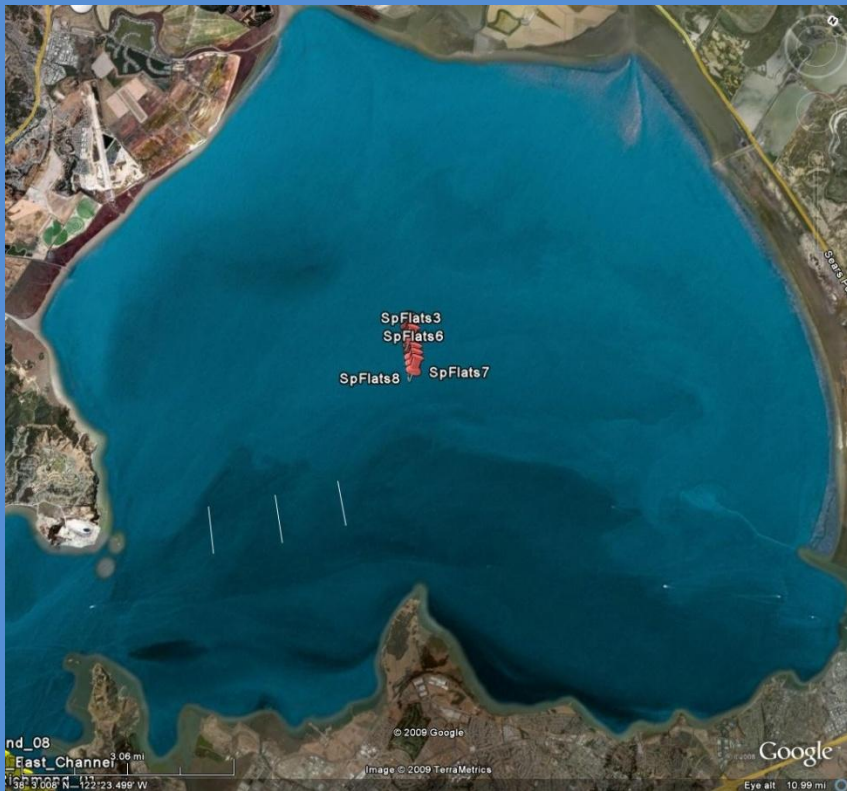# New Sites for 2010

- Richmond Bridge extension

Why?

- Complete cross section of San Pablo Bay-San Francisco Bay boundary
- Compare depth use over channel and shallow portions

Study Array

San Francisco Estuary 2008 - 2009
Monitor Locations

Carquinez Bridge

Benicia Bridge

Richmond San Rafael Bridge

Racoon Straight

Alcatraz Control

Golden Gate

Alcatraz Placement

Bay Bridge

SF 10 Placement Site

1 Suisun City Marina
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11 SP Bouy8
12 SP Buoy9
13 SP Buoy10
14 SanRafael Canal
15 Larkspur Ferry
16 Point Richmond
17 Berkeley Marina
18 Emeryville Marina
19 Emeryville Marina 2

N

Agency
• NOAA
• UC Davis

0   5   10   20 km

New Sites for 2010

- Flats Array

Why?
- Comparative array with channel for depth-habitat preference
- Information on direct vs meandering routes through bay

Range Tests

70% at 75 m radius
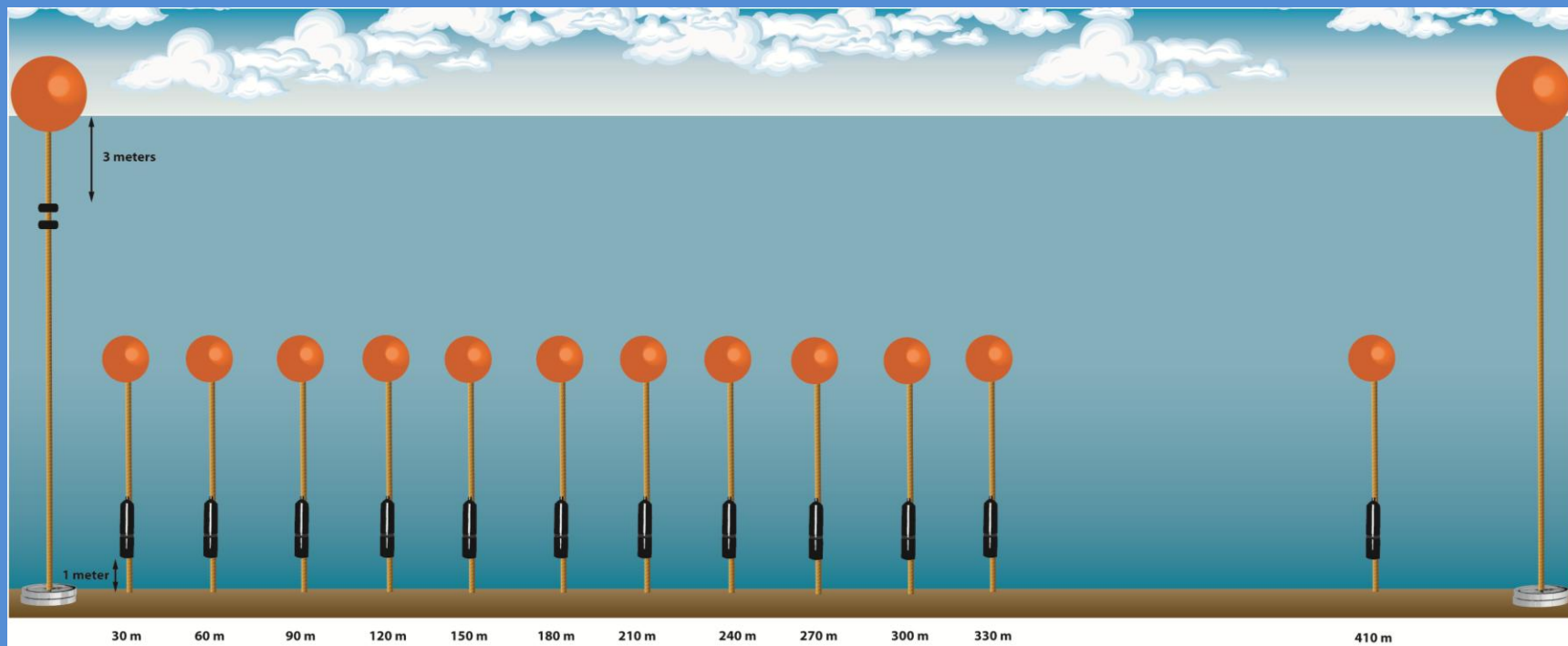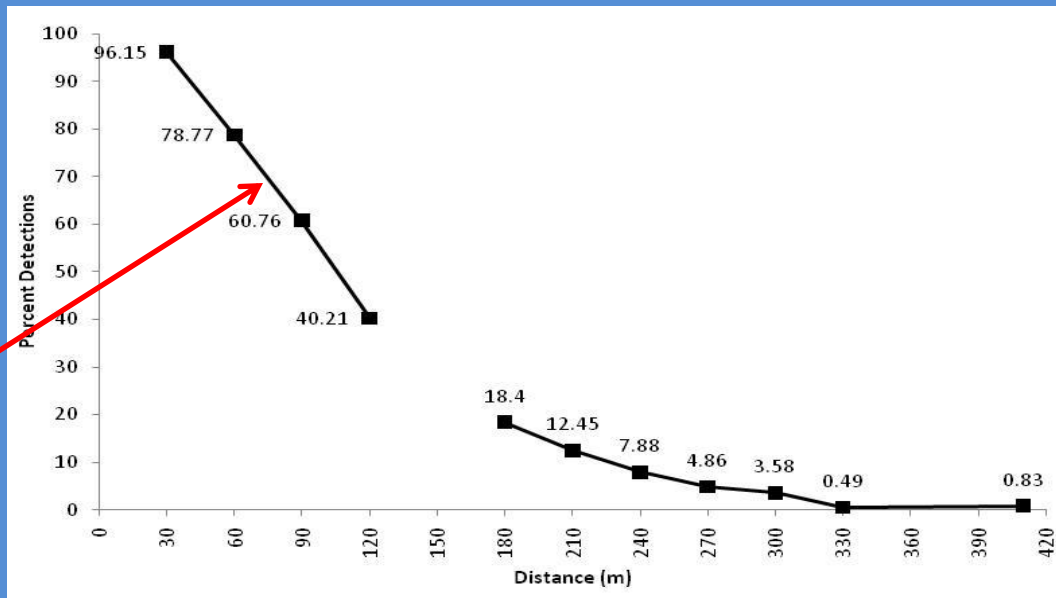
Release Strategy & Survival

Reach	Survival Prob.	n=100	n=500	LFC 2009	STH 2009
Feather River to Sacramento	0.9565	96	478		
Sacramento to Freeport	1.0000	96	478		
Freeport to Rio Vista	0.7273	70	348		
Rio Vista to Benicia	0.5000	35	174	309	163
Benicia to Richmond	0.6250	22	109	112	86
Richmond to Golden Gate	0.8000	17	87	89	62

- Overall good correlation with expected survival to Golden Gate
- Higher mortality than expected in San Pablo Bay
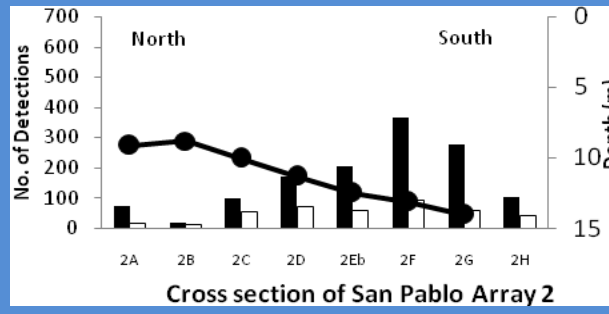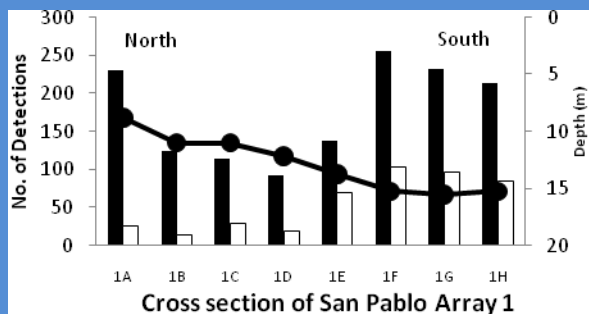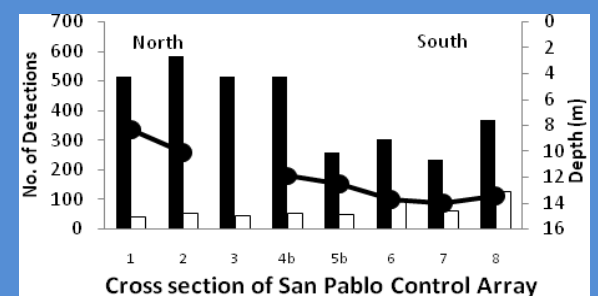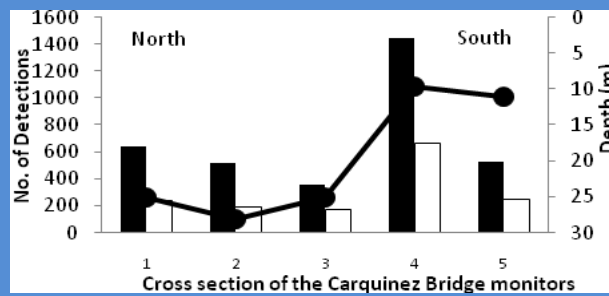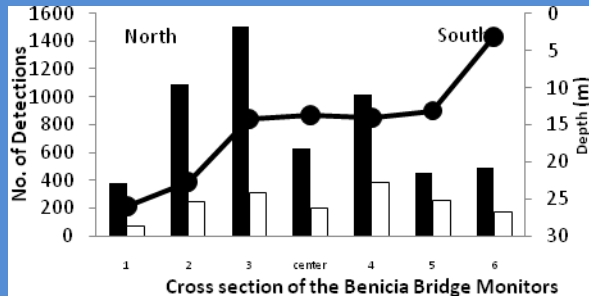- Lower mortality upstream

Q1: What are the general migratory patterns of salmonid smolts through SF Bay in relation to dredge and dredge placement sites?

Results to Date
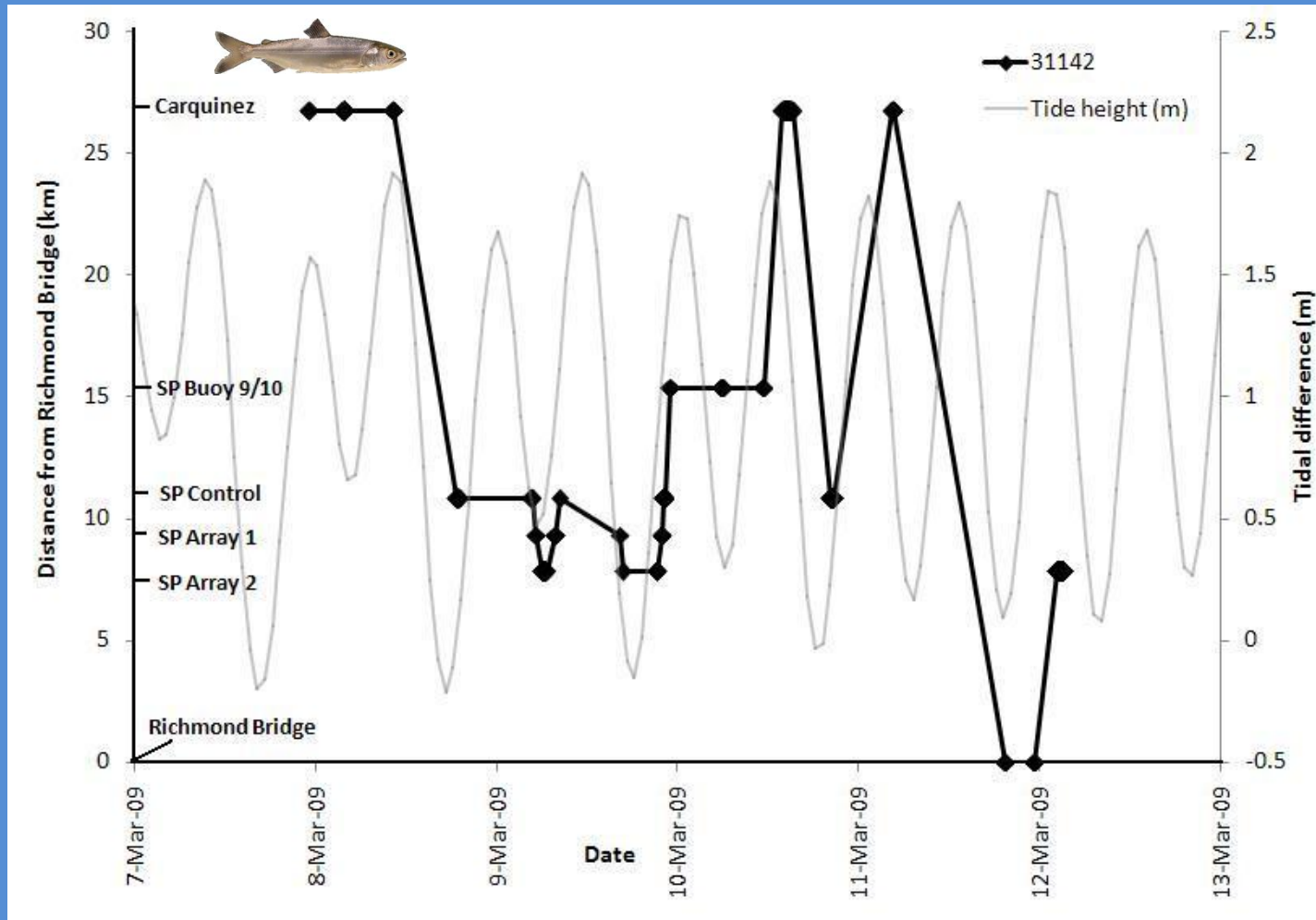
Many fish (both species) display repeated upstream-downstream movements, coinciding with tidal flows
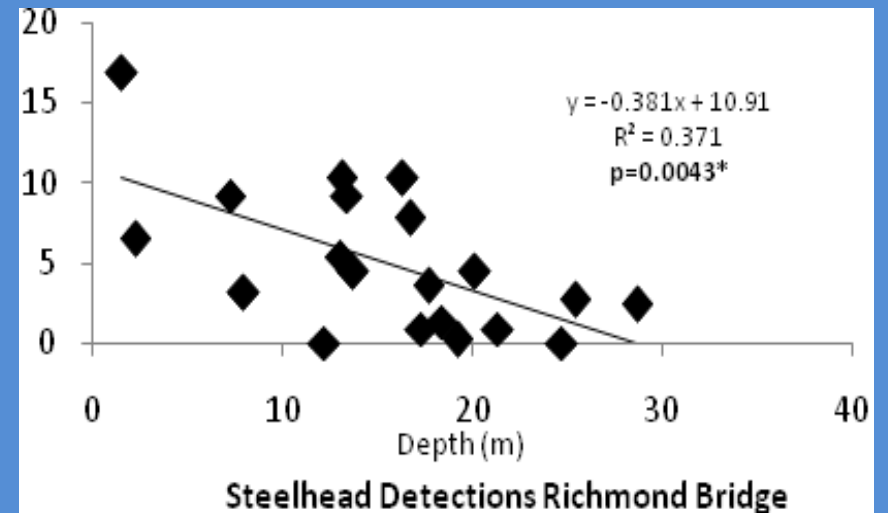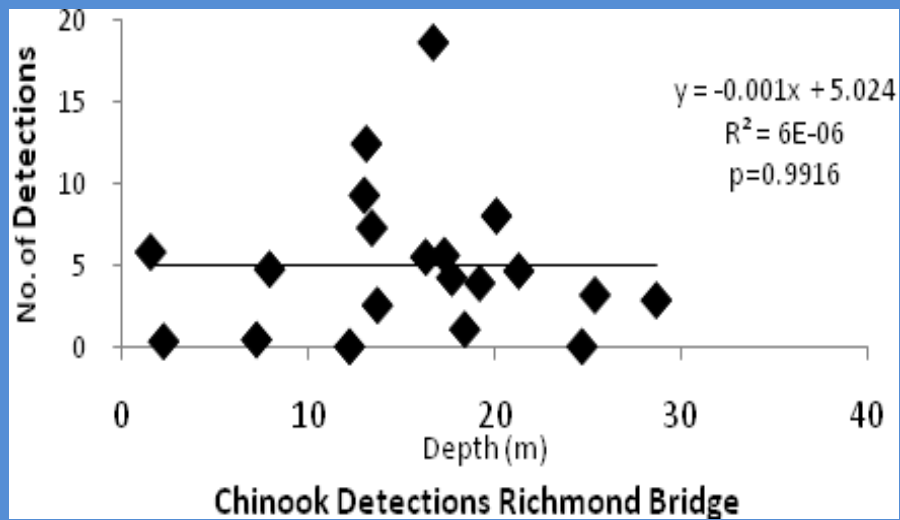
Channel or Flats?
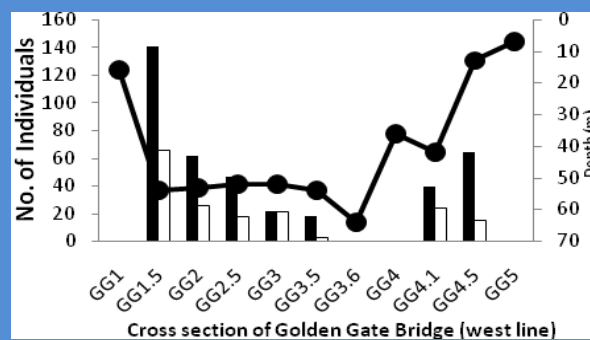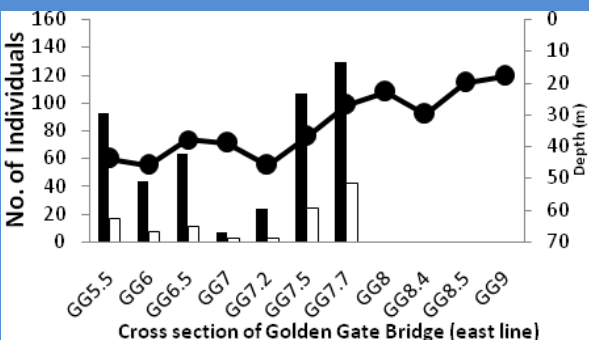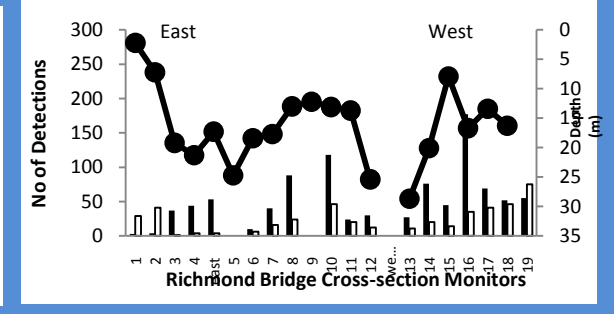
Steelhead

Chinook salmon

Chinook Detections Richmond Bridge

$y = -0.001x + 5.024$
$R^2 = 6E-06$
$p = 0.9916$

Steelhead Detections Richmond Bridge

$y = -0.381x + 10.91$
$R^2 = 0.371$
$p = 0.0043*$

Direct Routes?

- Instantaneous rates of transit through experimental array were **faster** than overall transit through reach (Paired t-test, p<0.001)

| Tag ID	Carquinez-Richmond	SP Control - SP Array 1	SP Array 1- SP Array 2
31284	0.38	2.05	1.90
31289	0.45	1.82	1.84
31376	0.35	2.53	0.09
31386	0.44	1.81	1.50
31389	0.41	1.68	0.12
31496	0.17	1.24	1.00
31578	0.61	1.31	0.06
31589	0.43	0.88	0.06
31618	0.39	1.40	1.41
31628	0.49	1.38	1.26
31636	0.47	1.70	1.22
31260	0.47	1.76	
31392	0.36	1.37	
31426	0.54	1.30	
31454	0.44	1.21	
31466	0.29	1.55	
31500	0.55	2.42	
31501	0.61	1.95	
31570	0.49	1.93	
31579	0.39	1.31	
31619	0.53	1.22	
31415	0.32		1.93
Average transit rate	0.44	1.61	1.03

Chinook salmon

Q2a: What is the residence time of salmonid smolts in particular reaches of the estuary (transit time)?
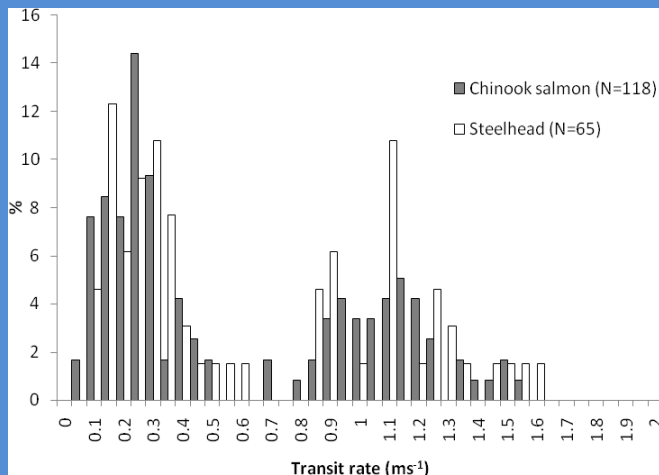
Results to Date
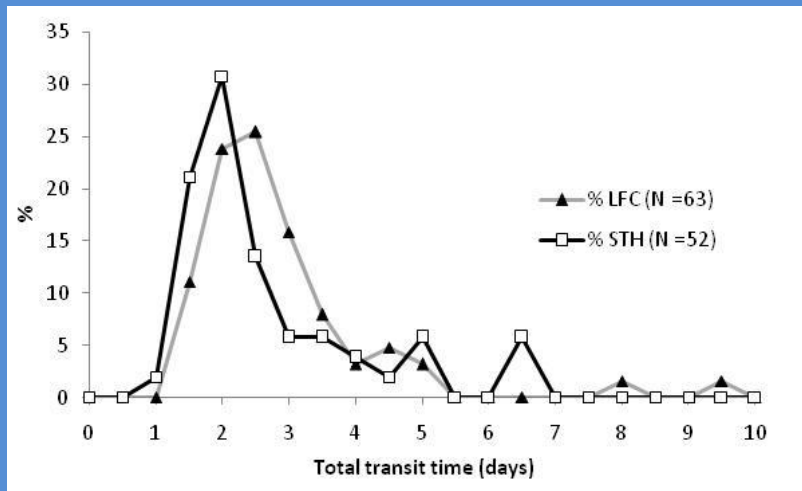
Transit time from Benicia to the Golden Gate
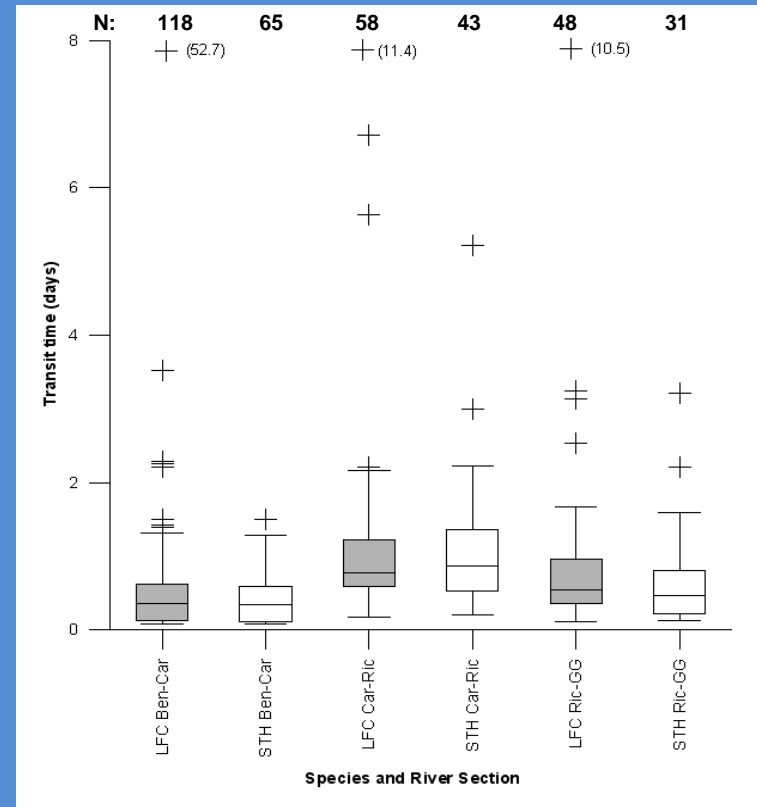
Transit time of Chinook salmon (LFC, grey) and steelhead (STH, white) in three sections of the Sacramento River system: Benicia (BEN) –Carquinez (CAR), Carquinez (CAR)–Richmond (RIC), Richmond (RIC) –Golden Gate (GG).
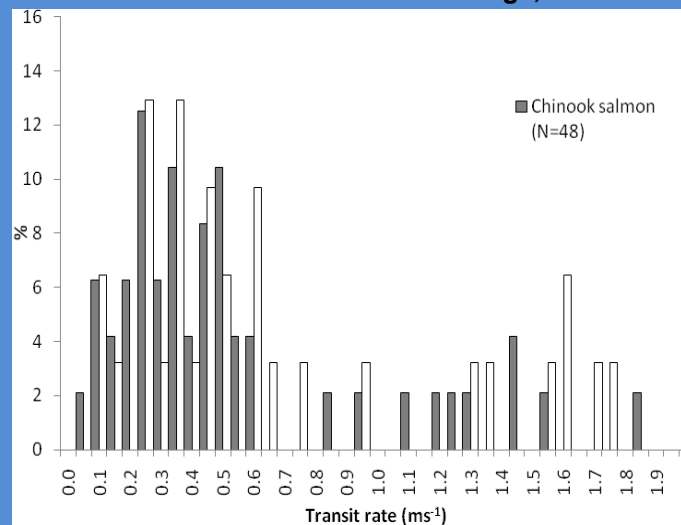
Results to Date

Transit rates (ms-1) for Chinook salmon (filled bars) and steelhead (white bars) from Benicia Bridge to Carquinez Bridge, 2009.
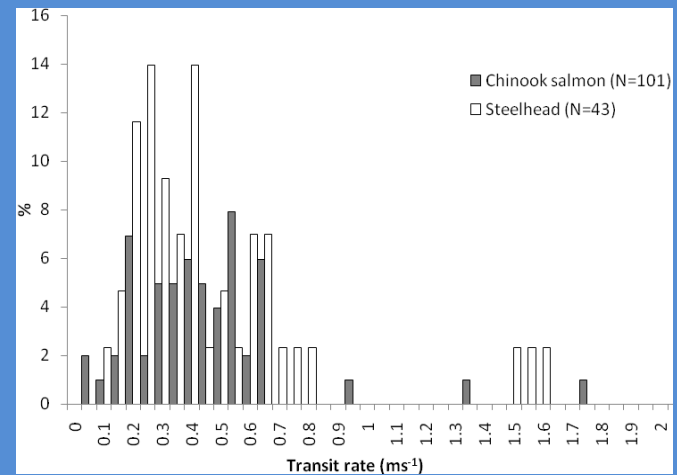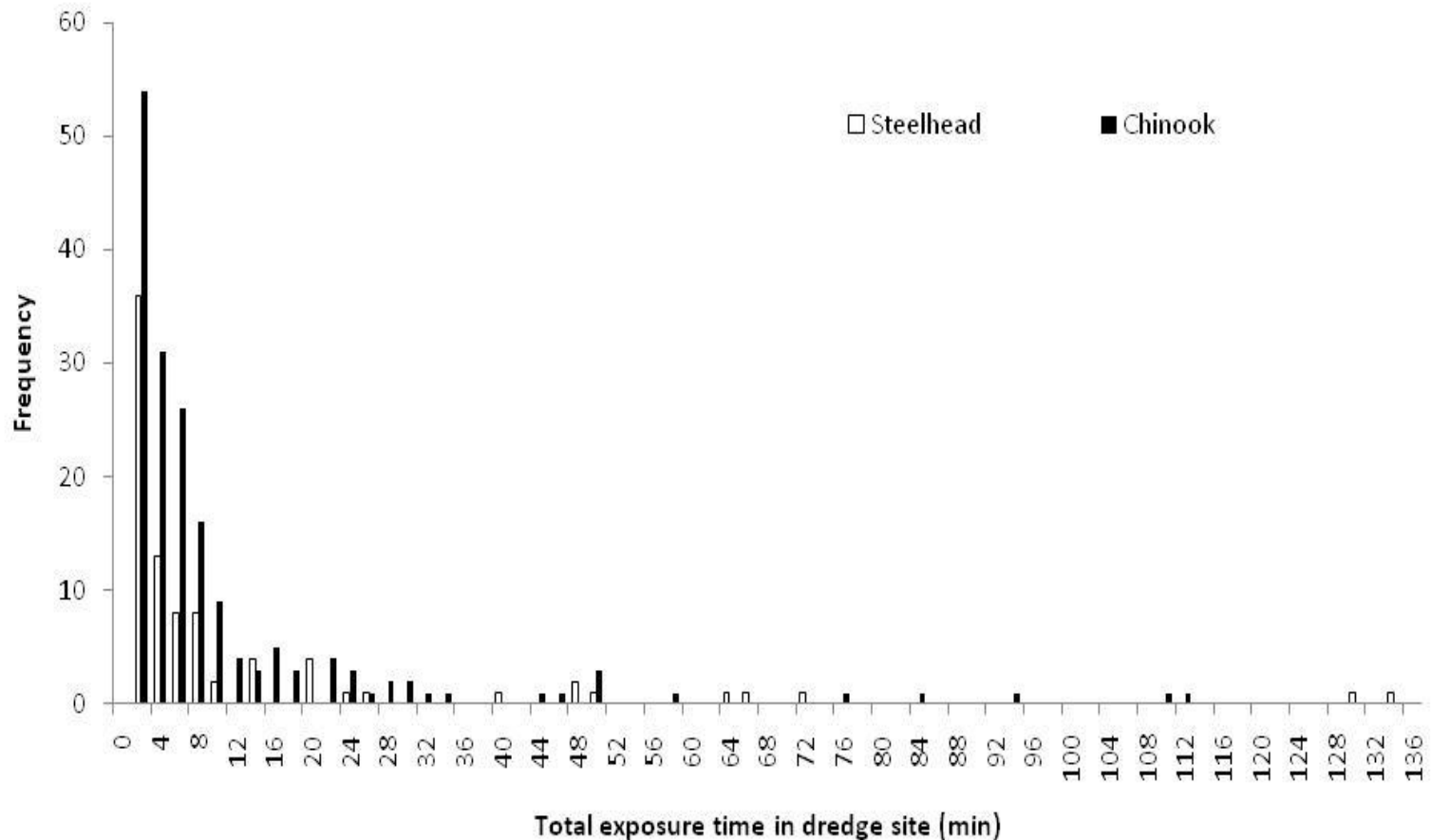

Transit rates (ms-1) for Chinook salmon (filled bars) and steelhead (white bars) from Carquinez Bridge to Richmond Bridge, 2009.

Transit rates (ms-1) for Chinook salmon (filled bars) and steelhead (white bars) from Richmond Bridge to the Golden Gate, 2009.

Q2b: What is the residence time of salmonid smolts at sites of interest (exposure time)?

General Exposure Time

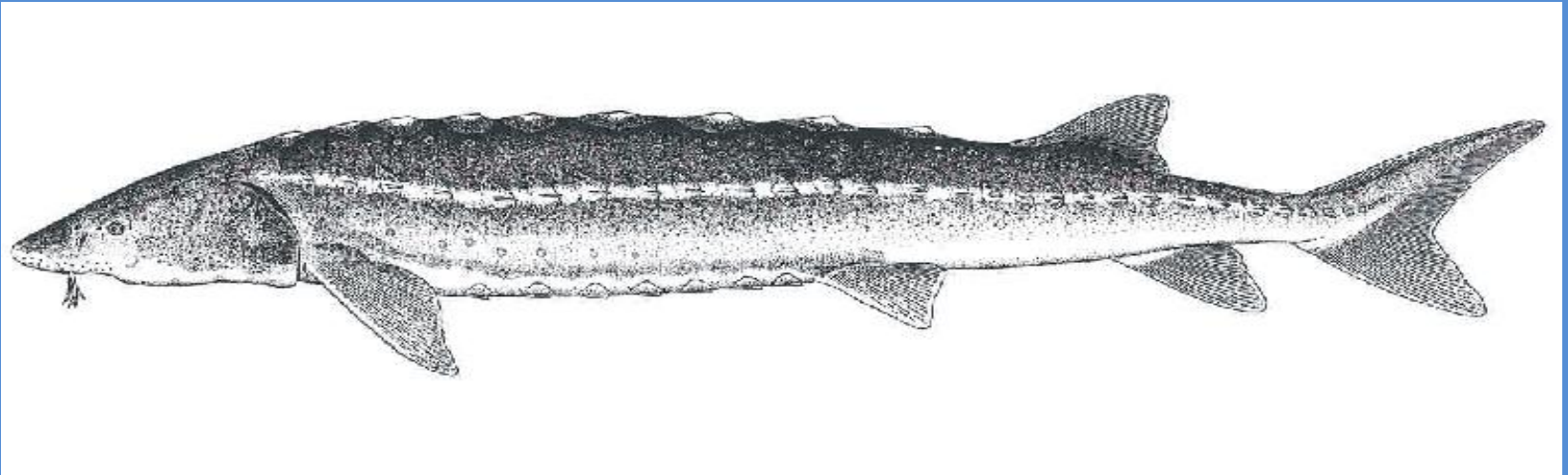**Total exposure time at a dredged site (marina or channel) by salmonid smolts in San Francisco Bay Estuary.**

Fish Presence at Dredged Sites

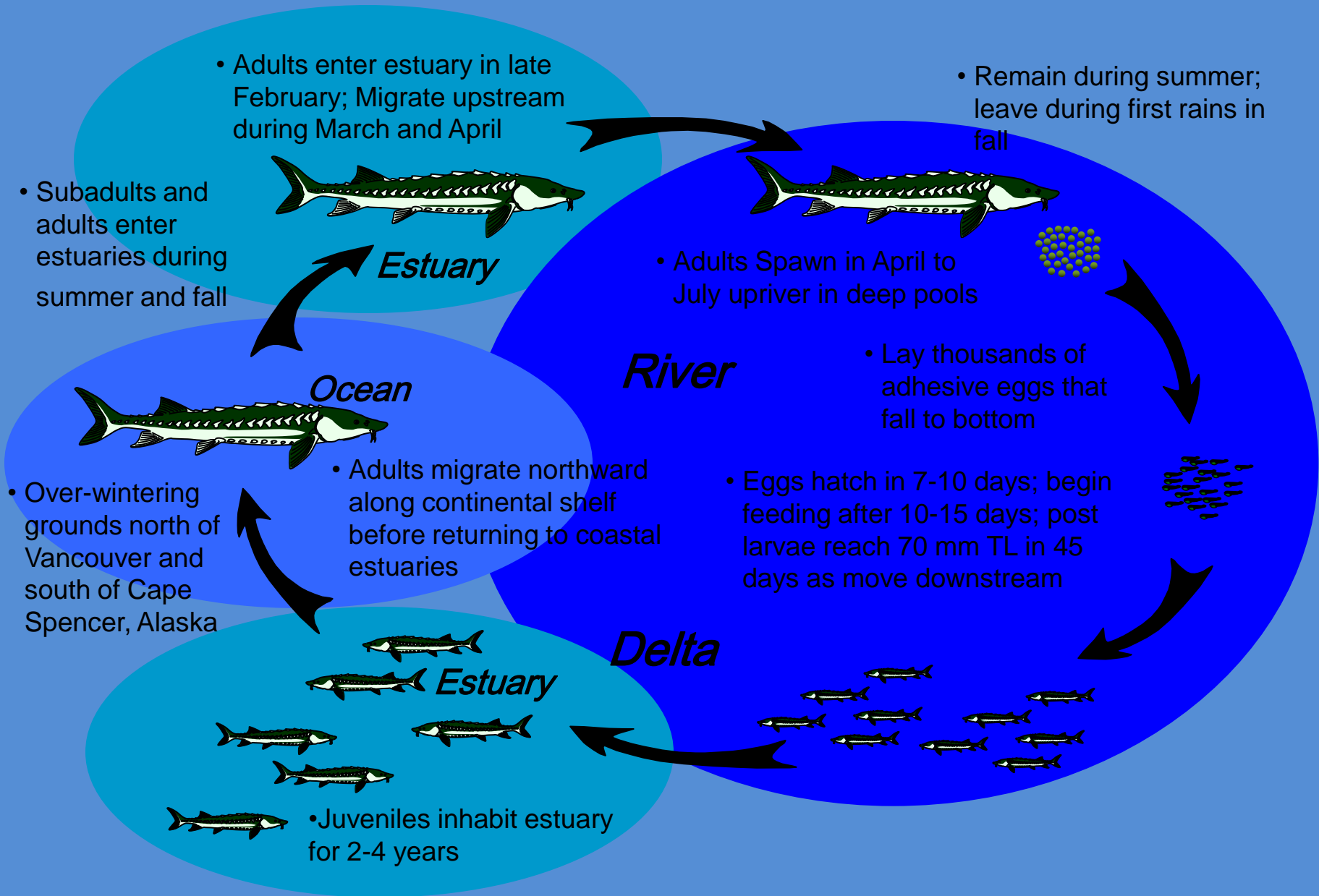| Station Type	Station Name	Chinook salmon		Steelhead	
		# Fish	# Detection	# Fish	# Detection
Marina/ Shoal	Berkley Marina				
	EmeryvilleA				
	EmeryvilleB	1	2		
	G3	5	160	2	22
	G5			1	1
	Larkspur Ferry 15			5	112
	MartinezMarina	156	1152	64	162
	MontezumaEast	4	308	4	149
	MontezumaWest	4	103	2	22
	PetalumaRRBridge	5	192	5	206
	Point Richmond			2	30
	PortSonomaMarina	4	50	3	7
	San Rafael Can 6				
	Suisun City Marina				
	Vallejo Marina C	12	36		
	Total	**168**	**2003**	**77**	**711**
Channel	SPBuoy7			1	1
	SPBuoy8	50	331	38	163
	SPBuoy10	38	240	2	5
	SPBuoy10b	3	7		
	Total	**80**	**578**	**39**	**169**

Summary

- Bay movements of salmonids affected by tidal influences, leading to a washing effect up and down stream

- Instantaneous transit rates > overall transit rates; movements may not be entirely directional within channels, but may include use of flats

- Overall transit times through the Bay is relatively short; less than 10 days

- Reach specific transit rates variable for both species and range from 0.1-1.9 ms^{-1}

- Cumulative exposure at dredge site monitors was low for both species; less than 12 minutes for most individuals

Green Sturgeon in the San Francisco Bay

- SDPS listed as "Threatened" under ESA April 2006

Life history of Green Sturgeon

• Adults enter estuary in late February; Migrate upstream during March and April

Estuary

• Subadults and adults enter estuaries during summer and fall

Ocean

• Over-wintering grounds north of Vancouver and south of Cape Spencer, Alaska

• Adults migrate northward along continental shelf before returning to coastal estuaries

Estuary

•Juveniles inhabit estuary for 2-4 years

• Remain during summer; leave during first rains in fall

River

• Adults Spawn in April to July upriver in deep pools

• Lay thousands of adhesive eggs that fall to bottom

• Eggs hatch in 7-10 days; begin feeding after 10-15 days; post larvae reach 70 mm TL in 45 days as move downstream

Delta

Q3: What are the spatial and temporal distribution patterns of green sturgeon in the estuary?
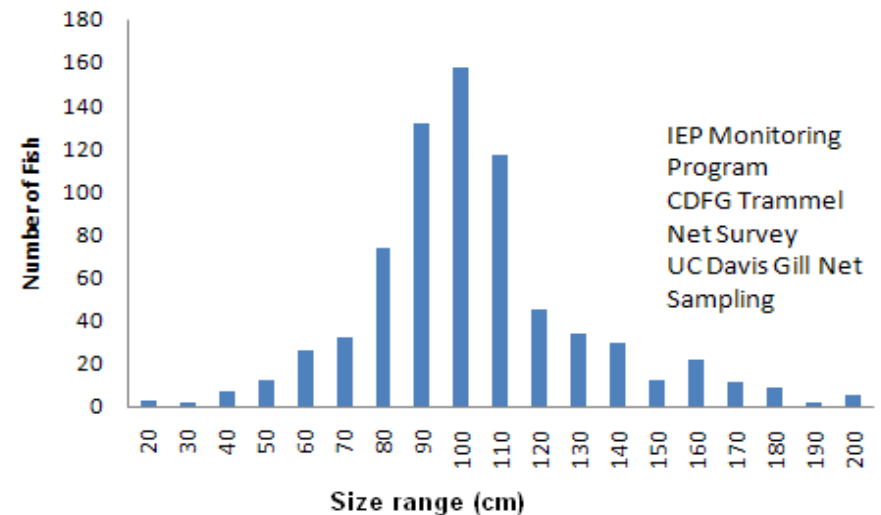
Distribution of Green Sturgeon in the Bay
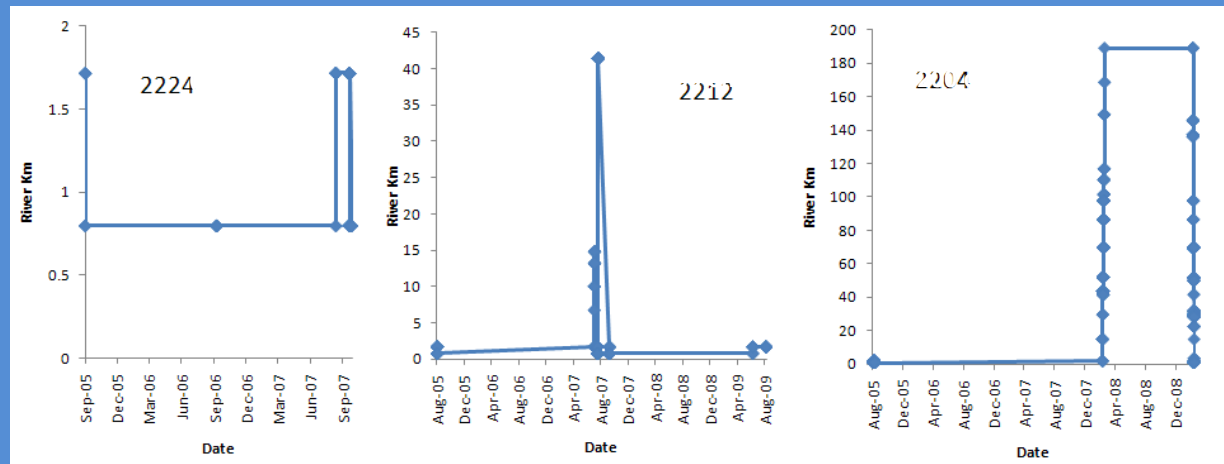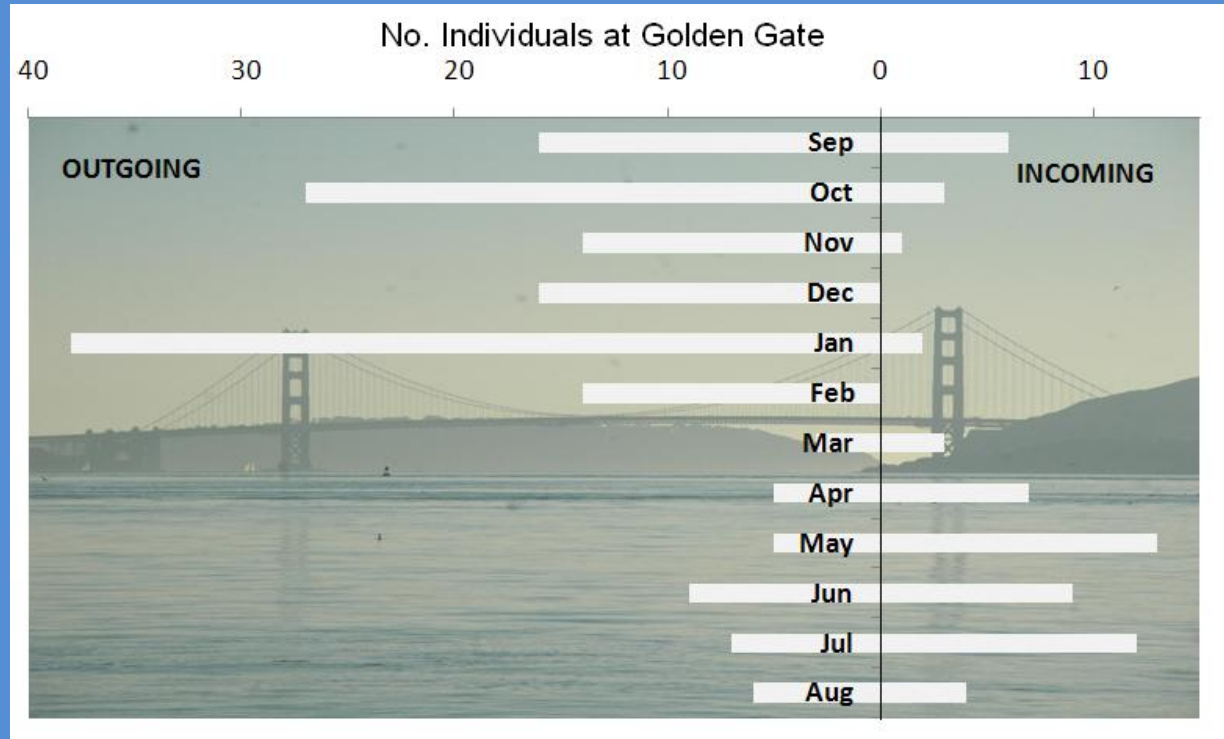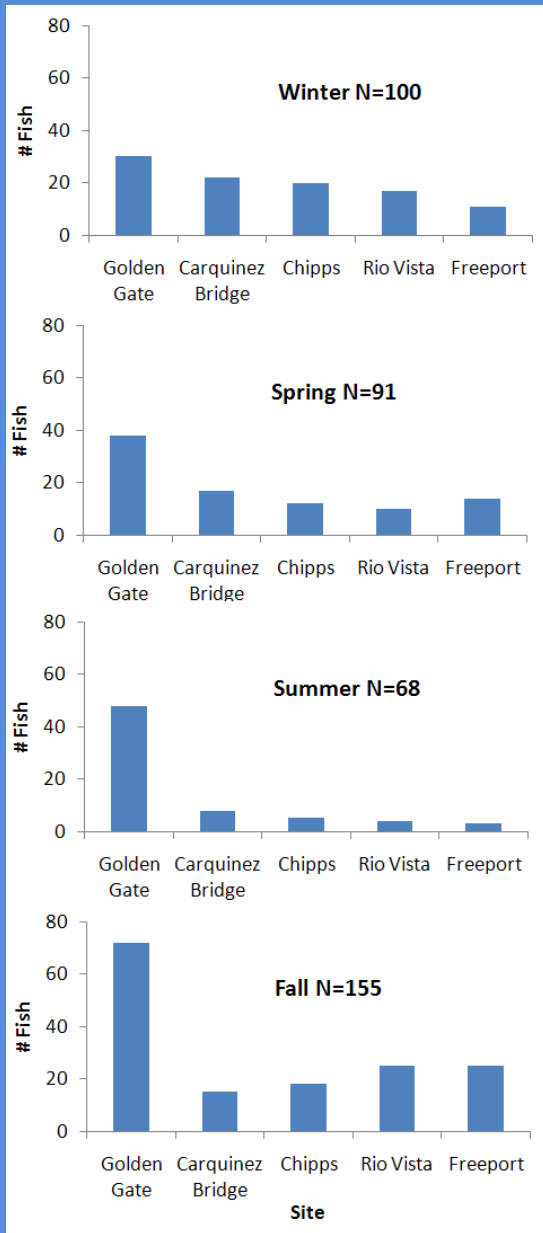
Historical Catch Locations
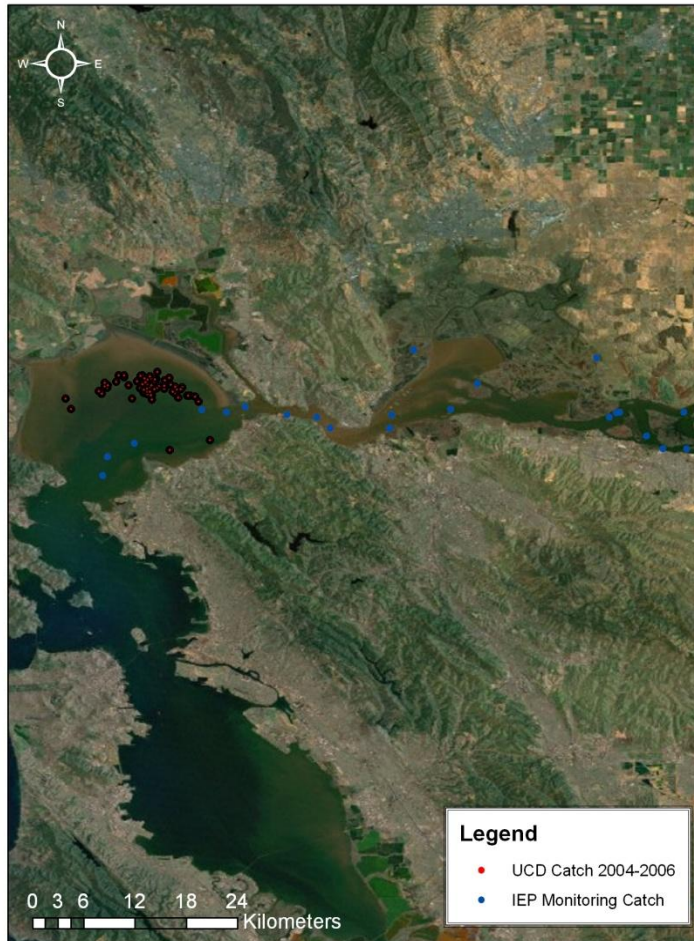
| Program	Sampling Method	# Fish	Size Range (cm)
IEP Monitoring Program	Various	23	19-101
CDFG Trammel	Trammel Net	732	47-209
UC Davis	Gill Net	209	55-204

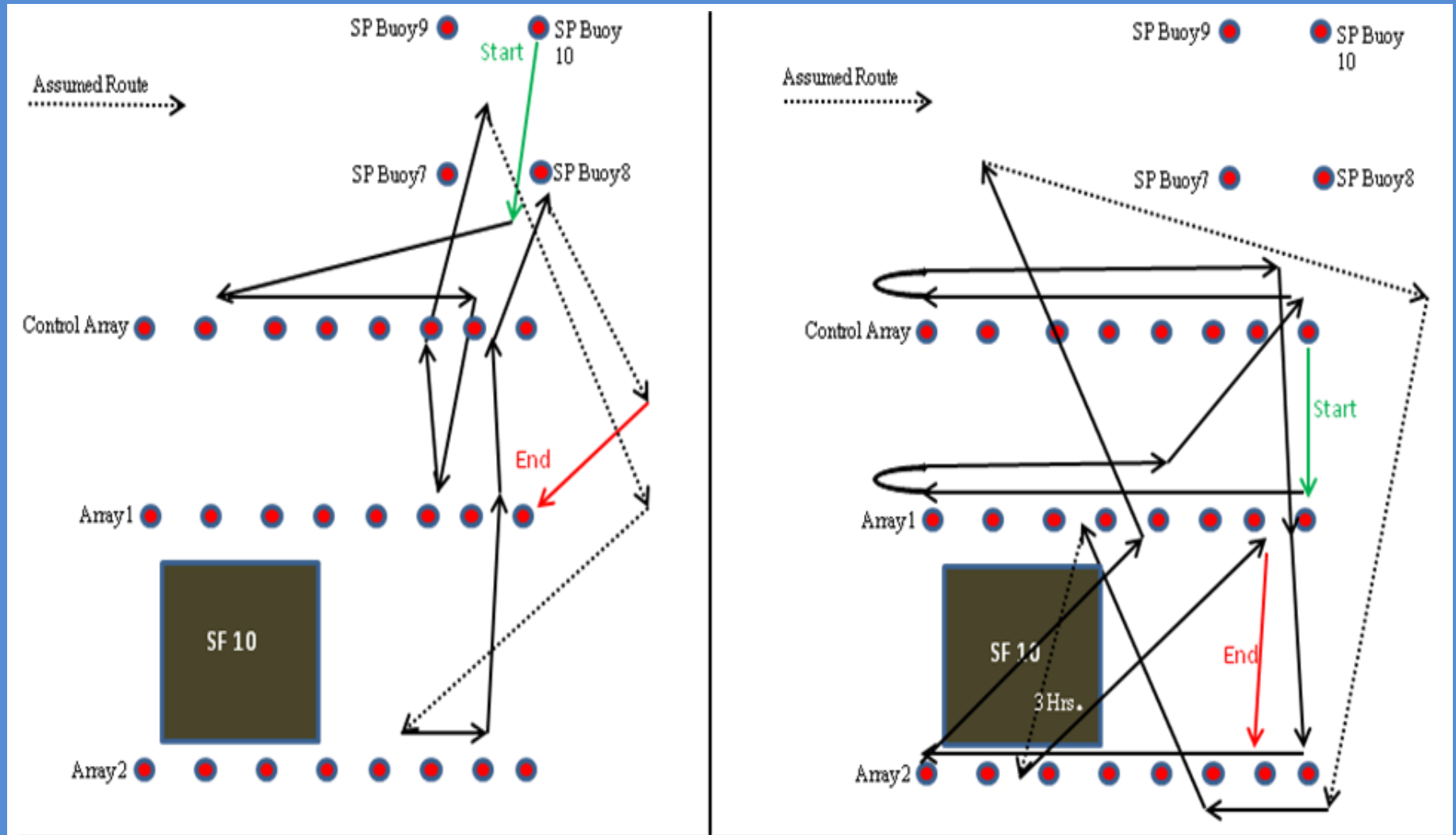# Seasonal Presence of Tagged Sturgeon

Transit Rates Through Bay

- Studied overall transit rates from Rio Vista to Carquinez and from Carquinez to Golden Gate
- Fish moved faster in winter than fall (P = 0.009)
- Fish moved faster downstream than upstream (P=0.032)
- No difference in transit rates by reach (upper and lower)
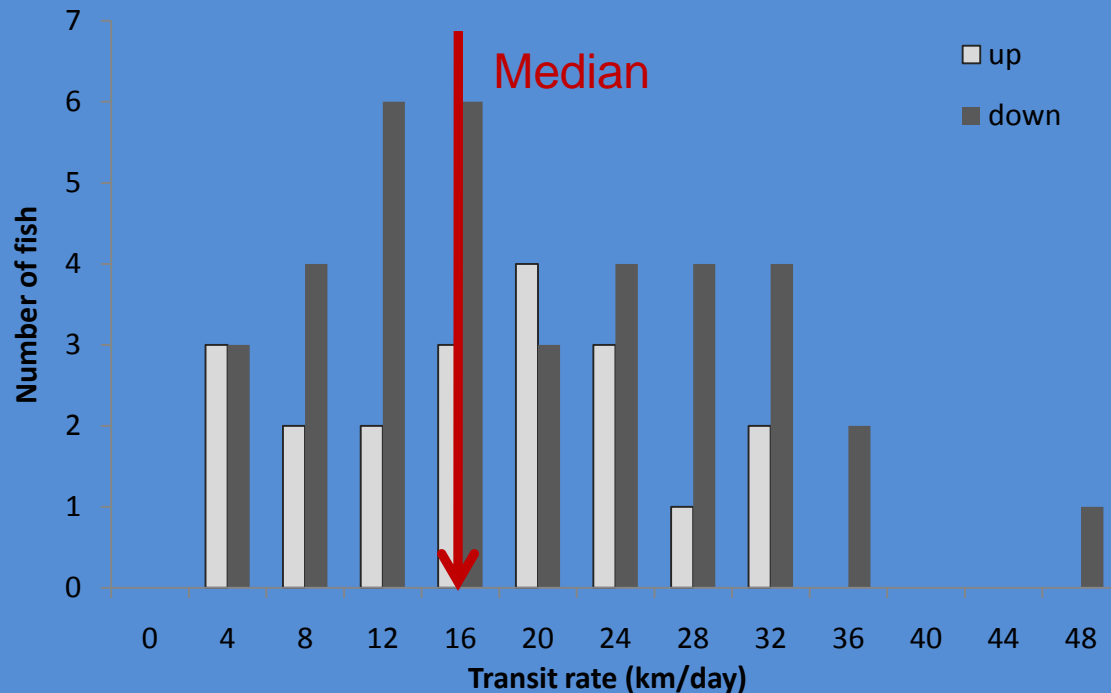
Movements Around Placement Site SF10

Exposure at dredged sites

From March-June 2009, 18 fish detected in Bay, 10 detected at dredged sites (exposure time [min])

Tag ID	Martinez Marina	Richmond Point	Vallejo Marina	G3 Channel	Total
217	34.3	20.2			54.6
219			682.5		682.5
224	18.6				18.6
2204	21.1			9.6	30.8
2237	7.1				7.1
2242		11.6			11.6
5447	252.7		149.8		402.5
5449	57.1				57.1
5450	30.7				30.7
10816	173.4				173.4
Average Minutes	**74.4**	**15.9**	**416.1**	**9.6**	**146.9**

(Two individuals (Tag IDs # 217 and 2237) were detected at the Alcatraz SE monitor for 21 minutes (13+8) and a single detection, respectively).

Expected Results 2010

- Describe frequency use of shallow flats/shoals for all three species

- Channel preference through SP Bay and Raccoon Strait.

- Transit time in relation to tidal state and currents (ADCP work)

- How much time do sturgeon spend in the estuary?

- Inter-annual variations (dry years vs. wet years?)

- Diel influence on behavior and movement patterns

Conclusions

•Green sturgeon of all sizes are found in the Bay area

•GS use flats and channel habitats; do they preferentially utilize one are over the other?

•Individuals distributed throughout bay seasonally, with summer having the least dispersal

• Transit through the Bay can be fast (a matter of days), but some reside in the Bay for extended periods

•In 2009 sturgeon were detected at 4 of 15 Marina/Shoal sites and not at SP Buoys 7-10, but in all cases only for several minutes.

•Sturgeon were detected at the SF Placement Site, but also only for minutes (max. 3 hrs)

•All movement results are of mature adults, further work is necessary to investigate use of Bay by younger age fish

2010 Timeline

2010	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Tagging and release of USACE fish	🟨											
Data Downloads (4/year)			🟨					🟨		**?**		**?**
Quarterly data QA/QC		🟨		🟨					🟨		🟨	
Analysis					🟨	🟨	🟨	🟨	🟨			
Draft Report									🟨			

Future Steps

- Towards an ecosystem-based management: suite of native species (including sevengill sharks).

- Climatic influence on migratory behavior (wet vs dry years)

- Fine scale movements and avoidance behavior in relation to human activities.

- Transit time in relation to tidal state and currents (ADCP work)

- Integration of South Bay sites?

Acknowledgements